

Improving the Representation of Human Factors in Operational Analysis

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ABSTRACT

Operational Analysis (OA) supports a wide range of military decisions, from tactical level through to campaign implementation. As all military operations are human activities, there is a requirement to deliver appropriate representation of human issues in OA advice to UK Ministry of Defence (MOD) decision-makers. It has long been acknowledged that in a number of OA models, containing humans with group behaviours, there is insufficient consideration of key human factors (HF)/human issues. A reason given by the OA community is that the Human Sciences (HS) community do not have the required data in a readily useable format for their OA models. Correspondingly the HS community have argued that the analysts do not adequately define their requirements. Defence Science & Technology Laboratory (Dstl) was tasked to identify a common set of HF to be considered for inclusion within OA models, and to review and capture the key interfaces and issues between the OA and HS communities. This latter task aimed to continue to improve the working relationship between the two communities via a process promoting a shared understanding, and flow of information and data between the communities. The study determined that there was no common set of human factors for inclusion within OA models. The key set of HF was dependent upon the context, the question to be addressed, and the model's level of abstraction. A draft Good Practice Guide was developed to capture an auditable process by which the OA and HS communities could exploit each others areas of expertise in order to inform their respective research programmes. This was validated and refined using existing OA models.

1 INTRODUCTION

Operational Analysis (OA) supports a wide range of military decisions, from tactical level through to campaign implementation. As all military operations are essentially driven by human activities, there is a requirement to deliver appropriate representation of these human issues in OA advice to Ministry Of Defence (MOD) decision-makers.

The following research study was designed to address the UK MOD requirement to develop improved OA model outputs by improving the representation of Human Factors (HF¹). The initial stages of research were undertaken over the period from January 2006 until March 2009. The detail of the study can be found at Ref [1].

This paper provides an overview of the study activities and summarises the key outcomes and exploitation.

¹ Human Factors (HF) refers to the academic/theoretical/practical understanding of the human in the system, and its application.

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2 MILITARY NEED

Where OA models contain humans and systems with group behaviours, then they should also include key human factors and assumptions about these behaviours. This should then enable the model to represent the differing behaviours which could influence operational effectiveness and the analyst could use the data to represent these factors in the OA models. Ideally any empirical data would have been reviewed and any strengths and weaknesses recorded. However, human factors are not simple to represent in the OA models as their very nature means that there will be differing degrees of inter-dependency between them. This then increases the complexity when attempting to produce any quantitative data for use in the OA models.

There is a recognised problem that OA models do not always adequately take account of operationally significant Human Sciences (HS²) issues. There have been a number of reasons for this. The analysts argue that the HS community do not have the required level of definitive data on the behaviour of humans in complex systems and networks. The HS community argues that the analysts do not define their requirement in enough detail for it to be addressed.

The following example of an email request, from an analyst to the HS community for support to an OA model, neatly captures the military need:

“Hi

I was wondering whether you or your various colleagues in HS could give us a bit of a help by providing some information for our model. I hope I've come to the right person. We're currently in the process of verifying and validating a model and we're trying to include some soft effects and human factors in the mix. We're particularly looking for data/insights on the effect of fatigue, familiarisation with the terrain, experience and leadership on battlegroup sized operations (particularly tempo and mission effectiveness).

If you've got any data to hand along those lines, it would be great,

Many thanks,

(OA Modeller)”

This email highlighted the following three main issues, all of which have been brought into sharp focus over the course of the study:

- First, that a model has been built in answer to a customer question and is at the ‘validation’ stage yet only post this stage is HS input sought.
- Second that a non-HS specialist has already decided which HF are relevant to the model (though this would generally have been informed through Historical Analysis).
- Third, that there is an explicit assumption that the HS community can respond meaningfully, when no context is given to the problem space or definition provided of the data requirement and how it will be incorporated.

The HS community simply cannot answer this request for help meaningfully given these constraints and would need far more information to bound the question.

Conversely the OA community are continually frustrated by the perceived inability of the HS community to provide a straight forward response to their queries. HS responses tend:

² Human Science/Scientist (HS) refers to the scientific disciplines and community of experts practicing in and with expert knowledge of HF.

- To be overly complex
- To lack supporting information/data in a format is easily used to inform/support an OA query
- To lack (in the absence of any available theory/previous research) provision of an informed opinion that could then be followed-up with more grounded data

In addressing the study requirement, a review of the balance of issues on either side was required in order to continue to improve the working relationship between the communities.

There is a clear need to forge stronger understanding between the OA and HS communities, in order to identify and understand the human and system group behaviours involved, the Human Sciences factors which influence them, and then develop a plan to improve their representation in OA models. The improved models will in turn further de-risk responses to future UK MOD customer tasking.

3 STUDY PURPOSE AND APPROACH

The purpose of the study was to:

- Develop an effective collaborative working relationship between the OA and HS communities.
- Identify and agree a common, small set of key human aspects and factors, which influence networks or systems that have group behaviour, for inclusion in OA models
- Provide a basis upon which to focus the future HS research programme.

This study was a collaborative activity between the OA and the HS community and was based on an iterative principle, whereby results from each stage were validated and of value in their own right, but also informed the next stages.

The study approach was broken down into the following broad tasks:

- Task 1: Identify the key representatives from each community to contribute to the collaboration, define the problem space from the OA domain perspective and identify the key group behaviours and corresponding HF involved
- Task 2: Prioritise the HF identified in Task 1, by the greatest level of impact to Operational Effectiveness, and then identify a common, small subset of variables for use in the OA models. (This was amended to create a framework with key HF themes through which the HF relevant to the customer question could be examined)
- Task 3: Using the framework developed in Task 2, identify and agree relevant HF influences in a use case, i.e. peace support OA model (DIAMOND³). Then determine the availability of data to represent the HF identified in the model. This task would also capture the key interfaces and issues between the OA and HS communities.

The outcomes for the above tasks together with lessons learned were then distilled into activities of good practice and captured in a draft good practice guide (GPG) as part of the research exploitation outcomes. This draft GPG was devised for application across the OA community by the analysts in order to facilitate the consideration/inclusion of HF in OA models.

The original basis of the study was extended in order to further test and validate this process as follows:

- Task 4: Using lessons learned from Task 3, repeat the theme based workshop to identify and agree those influences important to DIAMOND, amend the process and update the GPG as required.

³ DIAMOND - DIplomatic And Military Operations in a Non-warfighting Domain

- Task 5: Repeat the theme based workshop to identify and agree HF for inclusion for a war fighting OA model (COMAND⁴). Again, from the outcomes, refine the GPG with regard to application to other (war fighting) models

As the study progressed and findings emerged, the boundaries between these tasks became somewhat blurred, as practical considerations determined the most pragmatic ways forward.

4 STUDY METHOD AND ASSUMPTIONS

The majority of the tasks used workshops to achieve their results. Where wider consultation across Dstl was required a multi-disciplinary collaborative group provided guidance. Wider awareness and benchmarking against other HF modelling initiatives was conducted for cross-checking and validation. The inclusion of military personnel at the workshops was essential and invaluable in the generation of ideas, and the provision of advice, to ensure consistency with Operations.

It was assumed that for the study to be completed successfully, the participation of representatives from both the OA and HS communities was essential. In addition this task was to draw upon extant information/data regarding HF; therefore, the development of new HF research was outside the remit of this study.

5 STUDY OUTCOMES

The following section outlines the activities of each of the above tasks together with corresponding outcomes.

5.1 Task 1: Identify a Collaborative Group, Define the OA Problem Space, Identify the Key HF Influences Involved

This task comprised the following three main elements:

- Identifying members for a ‘Collaborative Group’ to contribute to the research
- Defining the OA problem space
- Identifying the group behaviours and corresponding influences within the OA problem space. Facilitated workshops were used to illicit and capture the required information for use in subsequent workshops.

5.1.1 Task 1.1 Identification of Key Contributors to the Study

The first workshop brought together a wide variety of possible interested parties within Dstl. From this, a group of both OA and HS community Subject Matter Experts (SMEs) were identified who would be willing to become part of a ‘Collaborative Group’. This group’s remit was to provide oversight and guidance on the study and where appropriate ensure coherence with other related developments or studies within the two communities and across Dstl.

This group initially comprised two OA specialists, two HS specialists, and two with experience across both areas. Although the profile of the Group changed over the course of the study, it was an effective and powerful source of advice and provided assurance of scientific rigour throughout the review process. In addition to this Collaborative Group, a review was also undertaken by both military personnel and a member of Dstl’s Historical Analysis team, to ensure coherence and validity of the output.

⁴ COMAND - C3 Orientated Model of the Air and Naval Domain

This first workshop also sought information from participants on similar work that has been, or was currently being, undertaken in this area. This was followed up throughout the duration of the study via a Study Coherency Group [Ref 2].

5.1.2 Task 1.2 Definition of the OA Domain Problem Space

Using members from the Collaborative Group, a second workshop was arranged to develop a mutually agreed understanding of the real world problem space addressed by the OA domain, and identify the systems behaviours and HF involved. The aim of the second workshop was quite ambitious not only in terms of the desired output; but also, in the novelty of the approach; as this was the first workshop bringing representatives from the two communities together to achieve a relatively concrete output from unfamiliar perspectives and constructs. There were likely to be fundamental differences of understanding and language between those from each community. It was therefore important to establish a framework of shared understanding upon which the workshop participants could build.

To this end, the core team sought advice from the OA community on how best to represent the MOD problem space addressed by the OA. For this study the MOD problem space was bounded by timeliness and operational type. Timeliness was viewed in terms of Force Readiness and operational type provided an idea of the severity and degree of involvement in military tasks. Both concepts are familiar and employed by the military Ref [2]. This framework served to assist the HS community in understanding the OA problem space and was agreed to encompass the types of OA models that currently exist or are likely to be developed.

Having agreed a framework there was now a need to bridge the gap between this overarching OA domain problem space and a specific context/problem space that an OA model would normally be seeking to address. It was therefore agreed that a set of Phenomena⁵ should be generated to provide this context. In addition, a series of 'lenses' representing differing HS perspectives, should be used to identify HF which have an influence within these Phenomena and for this the Physical, Information, Cognitive, Organisational and Social (PICOS) Domains⁶ were employed.

5.1.3 Task 1.3 Identification of Group Behaviours and Corresponding Influences

This process saw the generation of many ideas, some of which were subsets or underlying influences of others. The military input to this stage was particularly valuable as it allowed an injection of 'real world' operational experience. Participants then agreed which of these ideas could be expressed as 'Phenomena' and taken forward into the next stage. The following six key 'Phenomena' were identified:

- Achieve/lose control of pace of operations
- Change in support
- Gain/loss of force cohesion
- Failure of force elements to participate in the action
- Fratricide and collateral damage
- Surprise.

From the above six Phenomena identified five were chosen by the group to take forward to the next stage. Surprise was omitted as it was agreed that this context was already covered by the five Phenomena put

⁵ Phenomena; 'behaviour or state changes attributable to the presence of humans in the system, which can readily be related to a value construct such as effectiveness'. E.g Loss of Force Cohesion.

⁶ PICOS Domains were developed from an idea in the US Network Centric Conceptual Model. These domains are defined at [Ref 2; Annex A].

forward. Full definitions for the above Phenomena (as generated by the workshop participants) are provided in [Ref 2; Annex B]. Using the Phenomena identified together with the PICOS domains over a hundred HF influences were generated.

During the workshop, assumptions and issues were recorded however the most important observation was the issue of definitions. Whilst definitions were provided for PICOS, Phenomena etc. the study team found that these and other terms had very different meanings across the two communities. Within the project too, it became important to understand clearly what was meant by a 'human factor', HS, and an 'Influence' and other terms defined here.

The outcome of this workshop was recorded and participants were given the opportunity to comment on and amend the output. The most important reason for this was that the facilitator where possible included definitions or descriptors (including illustrative examples where necessary) of these HF Influences based on the discussions observed in the workshop. Participants were asked to verify these and add descriptors where these had not been adequately captured. These descriptors proved invaluable in the later stages of the research.

In terms of taking these findings forward, it had become evident that the HF influences identified were very dependent on both context (the problem space and the question the model was seeking to answer) and level of abstraction. As a result, it became clear that it was not going to be possible, as originally hoped, to identify a common subset of HF to be considered when developing any OA model.

5.2 TASK 2 Prioritise the HF and Identify a Small Common Set of HF/Human Issues for OA Models

In consultation with the Collaborative Group, Task 2 comprised three main activities; consultation exercise, a theming exercise and trial workshop. A summary of these and their outcomes are described below.

5.2.1 Task 2.1 Consultation Exercise

The agreed table of HF Influences: post Workshop [Ref 2; Annex C] captured in Task 1.3 was promulgated widely across Dstl for comment. Overall, although some additions were made to the influences identified, very few were deleted or moved. The table of influences including those contributions from the consultation exercise is detailed in [Ref 3; Annex B]. It became apparent that not only did the additions seem to show greater commonality across the Phenomena, but also, that the descriptors given by contributors were key to informing individual's assessment. For example, one contributor identified leadership as a factor. From the description provided it became apparent that the issue at hand was the individual commander's willingness to make a decision based on limited information and his/her attitude to risk taking. This fell far more into the area of decision making and situational awareness.

Although contributors were asked to assign a priority to the HF generated within each domain depending on perceived impact on operational effectiveness, this was only achieved with moderate success; again most felt unable to assign a generic importance to any one factor, without greater awareness of the context. The only criticism that emerged was the land centric focus of many of the examples. This was in part due to the context offered by the original example Phenomena but the point was noted as the team moved into the next stage of the study.

5.2.2 Task 2.2 Theming Exercise

On closer inspection by the study team, many of the influences identified appeared to start falling into

natural groupings, irrespective of the OA/Phenomena frameworks in which they had been generated. Rather than identify a subset of common key HF, it became clear it would be more appropriate to sort the HF influences into emerging themes. Using an iterative process, 13 HF themes were identified (of which there were two types; Intrinsic⁷ and Extrinsic⁸). On completion of the ‘theming’ process, titles and draft definitions for each theme were generated, which were deemed to encapsulate the essence of the underpinning influences. A table of the themes and their definitions was produced. This table was subsequently reviewed by the Study Coherency Group and military personnel, before being tested using existing OA models. The table of themes was further reviewed following each user case study (Tasks 3, 4 and 5). Before the final version

5.2.3 Task 2.3 Trial Workshop – Customer Question

As an additional task, during the consultation exercise, a small trial workshop was undertaken. This was to begin to assess the potential in terms of collaboration between the OA and HS communities at the earliest stage in the process of addressing a customer question. In this case a hypothetical customer question was proposed by the OA community, two of whom, together with four from the HS community, took part in a workshop to assess how a particular HF (fatigue) would impact on Operational Effectiveness (OE) in a particular task. The objective here was to determine if the HS participants could identify and prioritise the most important HF elements of fatigue and advise the OA community on the availability and maturity of data that could be provided for input into such a question.

From this workshop, several key lessons were identified. These included the need of the HS community to understand fundamental and underpinning information such as the purpose of the question, who was likely to use the answer and to what purpose. Also, there was a need for the OA community or customer to bound the problem in terms of environment (altitude and climate), time of troops in theatre (acclimatisation etc), force fitness (injuries) etc. Where the answer was not known, an assumption had to be made (and recorded). Through this, the OA community were able to appreciate that there was such a wealth of data and information available, across such a wide variety of disciplines within the overarching umbrella of HS, that the problem had to be narrowed down to allow meaningful engagement with the HS community. On the part of the HS community, they were also able to ‘park’ various issues or unknowns, in order to provide input. Again, a key element of this process was language, and the mutual understanding of terms.

Throughout the conduct of the study, it was becoming increasingly clear, that the original Task Three which sought to review the current maturity and availability of data for the OA models, and the level of representation of the identified HS factors in existing OA models, was both impractical and unlikely to be cost effective. The anticipated common subset of HF that should be incorporated into all OA models simply did not exist. Instead the study had derived key themes or umbrellas under which, depending on the context of the OA problem space, particular HF would come into play, at varying levels of importance and with many interdependencies. The HF would also have an impact at differing levels within model structures. In agreement with the customer, Task 3 was revised to take account of these findings.

5.3 Task 3 Test Theme Framework Developed in Task 2, Using an Example OA Model

This revised task gave the study team the opportunity to validate both the themes and process of engagement of the two communities and to build on the lessons identified to produce the GPG. For this task a peace support campaign OA model (DIAMOND) was used. This task comprised three key elements and their description and outcomes, are outlined below.

⁷ Intrinsic Themes – Groups of Influences, which pertain to human skills, abilities and behaviours such as decision making. These themes are measurable with existing data and assumptions.

⁸ Extrinsic Themes – Groups of Influences, which provide the means or capability to perform these human skills, abilities and behaviours such as Training. These themes are not easily measurable/quantifiable.

5.3.1 Task 3.1 Validation of Themes

This was undertaken both by external (to the project) benchmarking against other HF related model development and a cross checking of theme definitions against military meanings. The benchmarking exercise sought to ensure some degree of commonality in both outcome and lessons identified. The cross checking exercise aimed to ensure that theme names and definitions were in tune with common understanding of those terms particularly for the Armed Forces. Had the title and definition of a theme been in conflict with an existing understanding, alternative titles would have been found, an example being Doctrine.

5.3.2 Task 3.2 Testing the Process

A workshop was held with four HS participants (with disciplines relevant to the problem space), two analysts and a Military Advisor (MA). None of the participants, except the MA, had taken part in any of the previous workshops. Building on the lessons identified in the earlier workshop, the HS representatives were provided with a detailed briefing on the OA model before the workshop. The workshop tasked participants to consider the HF relevant to an existing OA model using the themes as a framework. It was the intention that HF identified would then be clarified, a comparison made against those already included in the model, and a priority agreed on those HF that should be taken forward for inclusion or amendment in the model. Unfortunately, the latter elements of this activity could not be undertaken due to time constraints, which in itself provided further valuable lessons to be recorded. However, a number of HF were identified which gave some initial direction to the OA model custodians on the validity of current HF within the model, and any that might need to be considered in the future .

The overall outcome was that the process in principle was a success and the themes offered structure and inspiration in generating ideas. The key lessons learned however, included the need to ensure precision from the HS participants (e.g. the word ‘morale’ as a factor was insufficient, more detailed information was required), to ensure the OA (and thus non HS expert) contributions were identified as such, and to maintain a fast pace throughout the day to ensure the objectives could be achieved. The one criticism made of the theme definitions was their apparent focus on ‘Blue’ own forces, rather than ‘Red’ opposing forces or any other neutral (Green) or unknown (Yellow) actors. This again was taken on board for future reference, though again, will be dependent on the context of the customer question. Following these exercises the themes and their definitions were amended slightly to reflect feedback. Some themes may be irrelevant to a given problem space, model or question, however that they are considered offers confidence that critical HF are not omitted. The final list of themes and their definitions are shown in the Table 1 below.

Table 1: Final Themes and Definitions.

Themes	Definition
Decision Making	The willingness and ability to decide on an appropriate course of action (e.g. minimising risk to own participants) based on changeable situational awareness.
Doctrine	Military doctrine articulates the fundamental principles that guide how our military forces conduct their actions. It is authoritative but requires judgement in its application. The principal purpose of doctrine is to provide a framework of guidance for the conduct of military operations, but it also serves to underpin our training and preparation. It is about how operations should be directed, mounted, commanded, conducted, sustained and recovered.
Force Fitness	The ability of the force element ⁹ to complete the operational task ¹⁰ given the demands of fatigue, illness or injury.
Host Population Belief Structure ¹¹	Thresholds of acceptability to host population's culture of own forces activities.
Logistical Support	The availability of the right resources, including functioning equipment and supplies, at the right place at the right time for the required tasks, and the capability to sustain this support.
Motivation	The desire ¹² of a force element to strive towards completing the required task/common goal.
Perceptions of Host Population	The host population's perception of how key aspects of their life have improved (or worsened) subsequent to non host forces activities.
Personnel Strategy	Overarching strategy outlining MoD personnel policies and processes including level of support given to families and service personnel.
Quality of Information	The usefulness of the information available (quality, credibility and timeliness) to inform decision making. This includes reliability of the C2 systems providing the information, including withstanding intentional opposing forces disruption.
Training	The effective teaching of skills, and development of military ethos and common understanding, underpinned by Doctrine, in order to execute operational tasks (Officers, Non-Commissioned Officers and Service personnel)
Trust	The belief that coalition force elements will follow through with their part of the operations plan/task and do so correctly (e.g. Senior commander's intent executed, or subordinates trust in leadership).
Understanding/Influencing Others	The ability to take into account and make use of differences and similarities in ethos, mindsets and training (e.g. within own forces, coalition, opposing forces, and host population) to achieve the objective.

⁹ Force element – Either UK, Coalition or Enemy Forces. May be a unit of any size, ranging from individual to brigade.

¹⁰ At the start of task (e.g. acclimatisation) and during the operation (e.g. deterioration of fitness over time).

¹¹ The shared belief, values, customs behaviours and artefacts that members of a society use to cope with and make sense of their world.

¹² Desire will be influenced by many factors e.g. perceived task difficulty and likelihood of success.

5.4 Task 4 Using Lessons Learned from Task 3, Repeat the Theme Based Workshop Using DIAMOND¹³ OA Model

On the basis of Task 3 outcomes, the repeat DIAMOND workshop format was amended. The main changes comprised:

- Extending the duration of the workshop from one to two days,
- Providing a briefing of the given OA model on the day of the workshop,
- Clarifying aims and roles of the participants,
- Presenting the themes as a tool rather than discussion point.

Of key importance to the process was the identification of participants with the relevant HS expertise and inclusion of a MA with recent operational experience. Pivotal to this was a sound understanding of the model by the HS point of contact through briefing and opportunity for question and answer.

Several lessons were again identified which informed the process and GPG. These included (for the HS participants) a need for a clarification of the question at hand (the model vs. the problem space) and practical examples of the model outputs. The OA participants required guidance on the incorporation of important HF as assumptions. From a process perspective, the need for participants, (including OA representatives) to attend all elements of the two-day workshop, the importance of using a skilled facilitator, and the need for the provenance of the Themes to be expressed were all found to be key. The process, themes and GPG were amended to reflect lessons learned.

For the DIAMOND model the HS participants identified seven HF areas that should be considered for inclusion in the model:

- Cultural understanding
- Risk of cultural bias in our understanding of non Blue elements
- Unexpected emergent behaviours as parties interact
- Ability to understand/discriminate complex information
- Level of trust between units/factions
- Number of dimensions of cultural group differences
- Command Personality or Mission Command.

For all these HF areas, the discussion that they generated identified whether the HS community could supply data readily or not, whether existing information could be better exploited to meet the need and whether there was a requirement for additional research. As an existing model, the practical issues of future funding will determine how much additional effort will be expended on these options.

5.5 TASK 5 Test Theme Based Workshop Using a Warfighting OA Model (COMAND¹⁴)

Key lessons which emerged in this workshop were:

- The importance of having an OA model presentation briefing reviewed by a HS representative, to ensure clarity and understanding by the HS community
- The need to reiterate that the role of the Themes were as a checklist rather than a rigid framework

¹³ DIAMOND - Diplomatic And Military Operations in a Non-warfighting Domain.

¹⁴ COMAND - C3 Orientated Model of the Air and Naval Domain.

- The need to allow participants to discuss priority HF for inclusion in the model after initial voting to foster consensus.

For the COMAND model, the HS participants identified five HF areas that should be considered for inclusion in the model:

- Acute fatigue, as part of Force Fitness
- Distribution of experience within the unit, in terms of training
- Timeliness of information, in terms of availability
- Individuals' understanding of their own level of understanding
- Trust in information.

Again, availability of funding to the model custodians for the inclusion of these HF identified is a key consideration in them being taken forward. However, in both cases it was illustrated that the processes can be used to ensure OA models are improved, better linkages made and better tasking and exploitation of HF research that may be incorporated into models in due course.

6 OUTCOMES FROM PROCESS PERSPECTIVE

From a process perspective there were two key outcomes from the above workshop:

- The first is a table of themes (shown previously in Table 1) which acts as a checklist so enabling the HS community to ensure all aspects the problem space are considered when identifying the relevant HF
- The second is a revised draft GPG [Ref 5; Annex B] reflecting all the lessons learned from the trials and validation activities. A key element of the draft GPG is the series of steps to deliver a structured workshop to identify the HF in a given customer question/OA model.

The facilitated workshop format has been proven to be most useful in achieving the desired outcome. Depending on complexity, this may (and most often will) require two days; it requires careful facilitation to ensure engagement by participants, and to maintain the pace required to achieve the goal.

6.1 Extract from the Draft Good Practice Guide

This extract [Ref 4; Annex B] details the steps through the auditable workshop process to identify relevant HF in OA model/problem space: Two facilitators are recommended and the elements of the workshop should be as follows:

- OA Briefing This should include the fundamentals of OA including how models are developed, how they are used (including timeframes etc.), for what purpose and by whom. Then an exploration of the customer question should be addressed including whether the model or the problem space is to be considered. It is also helpful, where possible if examples of the/a model's outputs are demonstrated. It is critical that the HS POC review the OA briefing prior to the workshop to ensure Subject Matter Expert understanding.
- Clarification of workshop purpose and how outcomes will be used. This is essential to ensure contributions do not state generalities but focus on the actual HF involved. The understanding that any HF proposed will need to be supported by existing theory and/or data, will focus participants on the level of detail required.
- Assumptions, issues and definitions. These should all be recorded as they arise, to ensure an audit trail of the process as well as allowing discussion and decisions to be made at a later stage.

- Generation of HF. The Themes should be introduced (with some explanation of their provenance) to act as an aide memoir and to 'sort' freely generated HF relevant to the question/model. The themes may be used in the context of all parties within the problem space. This ensures consideration is given to all possible areas of HF, though a particular Theme may be irrelevant to the problem space under scrutiny.
- Consolidation HF. The HF need to be discussed and consolidated within each Theme to identify the subject matter of the topic/area. This can be done by the group directly or with assistance from the facilitator, who can address any conflicting/duplicate topics/areas.
- Prioritisation of the HF. A voting system to identify each participant's top 5 or 10 key topics/areas should be used [depending on size of group and number of HF generated]. Scores should be discussed and voted on iteratively till top 5 or 10 HF are identified. Level of abstraction or impact on aggregation must be considered, though practical issues such as cost or data availability will also play a part. However difficulty of inclusion should not be a bar to the HF in question; a record should be made of omissions, and where possible the opportunity left open for its inclusion in the model at a later date.
- Way forward. Finally through discussion on the availability of HF data to inform the model/question, an initial outline should be given of what may be available to the OA community. A discussion can then be undertaken to agree what can be provided immediately, and what may take further research. Further meetings and liaison between the two communities should be agreed to take the work forward and ensure coherence and mutual understanding and manage each community's expectations.

It was intended to conduct a trial process to ensure its universal applicability. However, following a review of the draft and its intended audience, the customer suggested that there were still a few issues with the format to be agreed, and that the content should be applicable to the wider MOD audience. The completion of the GPG will form a key part of any follow-on task.

The final sections of the paper provide an overview of the exploitation of the research and a summary of the conclusions.

7 EXPLOITATION

Interest in this study and its outcomes continues to be widespread. In addition to the presentation at International Symposium of Military Operational Research (ISMOR) August 2007, international and pan UK MOD interest seeks to apply this outcome to contexts other than OA, such as the non-equipment Defence Lines of Development and the UK MOD Acquisition Process.

The approach has been employed to inform a number of key UK MOD research studies including Operational Degradation model element of the Future Capability study. In addition the approach has been employed in support to Defence Equipment and Support (DE&S) via Human Factors Integration Defence Technology Centre (HFI DTC) activities. In particular this study's Theme Framework has been exploited in the HFI DTC Social Organisational Framework study, and the study team has provided a short extract for contribution to the HFI DTC Handbook. The study has also been explicitly referenced in support to future MOD OA research studies.

8 SUMMARY AND CONCLUSIONS

This programme of research has clearly shown a journey of collaboration between two distinct communities who talk and think very differently. In order to mitigate the confusion and frustration that has

often been a feature in past working relationships, this study has developed an approach to facilitate coherence between the OA and HS communities in their ways of working within research. It has established a common language and understanding between OA and HS communities and together with an auditable process enabled identification and inclusion of relevant HF/Influences in OA. The approach has been refined and validated using existing example OA models. The areas and principles for good practice in OA/HS collaboration have been identified when addressing MOD questions and OA model development, and these have been captured in a GPG (2nd draft) in the form of a pamphlet, intended to be trialled with the Dstl audience.

As stated previously, this study was both innovative and intrinsically challenging and has, by necessity, had to change its direction and its aims. However, as a result, it has been able to offer a more widely applicable product (the GPG), whilst still offering the OA and HS communities a framework from which to begin the process of improving the representation of HF in OA models. In particular the research has, the established a process to bridge the gap to achieving of a common understanding to a given OA problem space between the OA and HS communities. It has also proved that early meaningful engagement of HS in shaping the OA requirement minimises the barriers to effective collaboration to the ultimate benefit of the Defence customer.

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